Refine Search

Your wildcard search against 10000 terms has yielded the results below.
Your result set for the last L# is incomplete.
The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Search Results -

Terms	Documents
(electro$ with valve$) and frequenc$ and (pwm$ or pulse$) and (fuel$ with inject$) and hetero$ and frequenc$ and ((sum$ or total$ or add$ or combin$) same (hetero$ or (radio adj frequenc$) or rf$))	1

Database: US Pre-Grant Publication Full-Text Database; US Patents Full-Text Database; US OCR Full-Text Database; EPO Abstracts Database; JPO Abstracts Database; Derwent World Patents Index; IBM Technical Disclosure Bulletins

Search: L58

Refine Search | Recall Text | Clear | Interrupt

Search History

DATE: Saturday, February 17, 2007 Purge Queries | Printable Copy | Create Case

Set Name side by side	Query	Hit Count	Set Name result set
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L58	(electro$ with valve$) and frequenc$ and (pwm$ or pulse$) and (fuel$ with inject$) and hetero$ and frequenc$ and ((sum$ or total$ or add$ or combin$) same (hetero$ or (radio adj frequenc$) or rf$))	1	L58
L57	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and (fuel$ with inject$) and hetero$ and (fuel$ with inject$) and (electromagnetic$ with valve$) and frequenc$ and ((sum$ or total$ or add$ or combin$) same ((hetero$ or (radio adj frequenc$) or rf$)))	0	L57
L56	L54 and (fuel$ with inject$) and (electromagnetic$ with valve$) and ((sum$ or total$ or add$ or combin$) same ((hetero$ or (radio adj frequenc$) or rf$)))	0	L56

L55	L54 and (fuel$ with inject$) and (electromagnetic$ with valve$) and frequenc$ and ((sum$ or total$ or add$ or combin$) same ((hetero$ or (radio adj frequenc$) or rf$)))	0	L55
L54	l50 or l52 or l53	34	L54
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L53	(4030292 | 3982393 | 3910240 | 3644868 | 2166968 | 3691430 | 4033122 | 3708980 | 4109300 | 3827237 | 2771867)![PN]	11	L53
	DB=USPT,DWPI; THES=ASSIGNEE; PLUR=YES; OP=OR		
L52	("4106448"| "4631638"| "DE 2608152A"| "DE 3419781A")[ABPN1,NRPN,PN]	4	L52
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L51	l49	4	L51
	DB=USPT,DWPI; THES=ASSIGNEE; PLUR=YES; OP=OR		
L50	("4106448"| "4631638"| "DE 2608152A"| "DE 3419781A")[URPN]	19	L50
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L49	4631638.pn. or 4106448.pn.	4	L49
L48	L47 and ((trigger$ or excit$ or actuat$) near2 coil$)	19	L48
L47	l45 or L46	28	L47
L46	@pd<=20030206 and (fuel$ with inject$) and (electromagnetic$ with valve$) and frequenc$ and ((sum$ or total$ or add$ or combin$) same ((hetero$ or (radio adj frequenc$) or rf$)))	5	L46
L45	@ad<=20030206 and (fuel$ with inject$) and (electromagnetic$ with valve$) and frequenc$ and ((sum$ or total$ or add$ or combin$) same ((hetero$ or (radio adj frequenc$) or rf$)))	25	L45
L44	@ad<=20030206 and (fuel$ with inject$) and (electromagnetic$ with valve$) and frequenc$ and ((sum$ or total$ or add$) same ((hetero$ or (radio adj frequenc$) or rf$) with combin$))	0	L44
L43	@ad<=20030206 and (fuel$ with inject$) and (electromagnetic$ with valve$) and (clock$ with frequenc$) and ((sum$ or total$ or add$) same ((hetero$ or (radio adj frequenc$) or rf$) with combin$))	0	L43
L42	@ad<=20030206 and (fuel$ with inject$) and (electromagnetic$ with valve$) and (clock$ with frequenc$) and ((hetero$ or (radio adj frequenc$) or rf$) with combin$)	0	L42
L41	@ad<=20030206 and (fuel$ with inject$)and (electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and ((hetero$ or (radio adj frequenc$) or rf$) with combin$)	0	L41
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L40	L37 and (first$ same (valve$ with current$)) and (second$ same (valve$ with current$))	1	L40
L39	L37 and first$ and second$	1	L39
L38	L37 and (valve$ with current$)	1	L38
L37	4106448.pn.	1	L37
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		

L36	L35 and first$ and second$	1	L36
L35	L34 and (valve$ with current$)	1	L35
L34	L33 and (great$ or big$) and small$ and ((cross$ adj section) or "cross-section")	4	L34
L33	L31 or L32	94	L33
L32	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and (fuel$ with inject$) and @pd<=20030206	91	L32
L31	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and (fuel$ with inject$) and @ad<=20030206	94	L31
L30	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and (fuel$ with inject$) and hetero$	0	L30
L29	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and @ad<=20030206 and (fuel$ with inject$) and hetero$	0	L29
L28	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and @ad<=20030206 and L25	0	L28
L27	L25 and L1 and @ad<=20030206	0	L27
L26	L25 and @ad<=20030206	155	L26
L25	(fuel$ with inject$ with valve) and hetero$	261	L25
L24	L22 and hetero$	0	L24
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L23	L22 and hetero$	0	L23
L22	(6209522 | 6422203)![PN]	2	L22
	DB=USPT,DWPI; THES=ASSIGNEE; PLUR=YES; OP=OR		
L21	("6792916"| "EP 1298307A") [ABPN1,NRPN,PN]	2	L21
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L20	L18	2	L20
	DB=USPT,DWPI; THES=ASSIGNEE; PLUR=YES; OP=OR		
L19	("6792916"| "EP 1298307A")[URPN]	0	L19
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L18	L16	2	L18
L17	L16 and hetero$	0	L17
L16	6792916.pn.	2	L16
L15	9792916.pn.	0	L15
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L14	("6792916")[URPN]	0	L14
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L13	L7	1	L13
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L12	(6422203 | 6209522)![PN]	2	L12
L11	("6792916")[PN]	1	L11
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES;		

OP=OR			
L10	L7	1	L10
DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR			
L9	("6792916")[URPN]	0	L9
DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR			
L8	L7	1	L8
DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR			
L7	6792916.pn.	1	L7
DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR			
L6	L5 and (vehic$ or car$ or automobile)	5	L6
L5	L4 and ((modulat$ or chang$ or edit$ or var$) near2 frequenc$)	11	L5
L4	L2 or L3	121	L4
L3	"electromagnetic valve" and (clock with frequenc$) and (pwm or pulse$) and @pd<=20030206	116	L3
L2	L1	116	L2
DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR			
L1	"electromagnetic valve" and (clock with frequenc$) and (pwm or pulse$) and @ad<=20030206	116	L1

END OF SEARCH HISTORY

Refine Search

Search Results -

Terms	Documents
L37 and (first$ same (valve$ with current$)) and (second$ same (valve$ with current$))	1

Database:
US Pre-Grant Publication Full-Text Database
US Patents Full-Text Database
US OCR Full-Text Database
EPO Abstracts Database
JPO Abstracts Database
Derwent World Patents Index
IBM Technical Disclosure Bulletins

Search: L40

Refine Search | Recall Text | Clear | Interrupt

Search History

DATE: Saturday, February 17, 2007 **Purge Queries** Printable Copy Create Case

Set Name side by side	Query	Hit Count	Set Name result set
DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR			
L40	L37 and (first$ same (valve$ with current$)) and (second$ same (valve$ with current$))	1	L40
L39	L37 and first$ and second$	1	L39
L38	L37 and (valve$ with current$)	1	L38
L37	4106448.pn.	1	L37
DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR			
L36	L35 and first$ and second$	1	L36
L35	L34 and (valve$ with current$)	1	L35
L34	L33 and (great$ or big$) and small$ and ((cross$ adj section) or "cross-section")	4	L34
L33	l31 or L32	94	L33
L32	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or	91	L32

	pulse$) and (fuel$ with inject$) and @pd<=20030206		
L31	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and (fuel$ with inject$) and @ad<=20030206	94	L31
L30	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and (fuel$ with inject$) and hetero$	0	L30
L29	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and @ad<=20030206 and (fuel$ with inject$) and hetero$	0	L29
L28	(electromagnetic$ with valve$) and (clock$ with frequenc$) and (pwm$ or pulse$) and @ad<=20030206 and L25	0	L28
L27	L25 and L1 and @ad<=20030206	0	L27
L26	L25 and @ad<=20030206	155	L26
L25	(fuel$ with inject$ with valve) and hetero$	261	L25
L24	L22 and hetero$	0	L24
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L23	L22 and hetero$	0	L23
L22	(6209522 | 6422203)![PN]	2	L22
	DB=USPT,DWPI; THES=ASSIGNEE; PLUR=YES; OP=OR		
L21	("6792916"| "EP 1298307A") [ABPN1,NRPN,PN]	2	L21
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L20	L18	2	L20
	DB=USPT,DWPI; THES=ASSIGNEE; PLUR=YES; OP=OR		
L19	("6792916"| "EP 1298307A")[URPN]	0	L19
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L18	L16	2	L18
L17	L16 and hetero$	0	L17
L16	6792916.pn.	2	L16
L15	9792916.pn.	0	L15
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L14	("6792916")[URPN]	0	L14
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L13	L7	1	L13
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L12	(6422203 | 6209522)![PN]	2	L12
L11	("6792916")[PN]	1	L11
	DB=PGPB,USPT,USOC;EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L10	L7	1	L10
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L9	("6792916")[URPN]	0	L9
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES;		

OP=OR

L8	L7	1	L8
DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR			
L7	6792916.pn.	1	L7
DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR			
L6	L5 and (vehic$ or car$ or automobile)	5	L6
L5	L4 and ((modulat$ or chang$ or edit$ or var$) near2 frequenc$)	11	L5
L4	L2 or L3	121	L4
L3	"electromagnetic valve" and (clock with frequenc$) and (pwm or pulse$) and @pd<=20030206	116	L3
L2	L1	116	L2
DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR			
L1	"electromagnetic valve" and (clock with frequenc$) and (pwm or pulse$) and @ad<=20030206	116	L1

END OF SEARCH HISTORY

Hit List

First Hit

Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Search Results - Record(s) 1 through 4 of 4 returned.

☐ 1. Document ID: US 5099802 A

L34: Entry 1 of 4 File: USPT Mar 31, 1992

US-PAT-NO: 5099802
DOCUMENT-IDENTIFIER: US 5099802 A

TITLE: Method of operating a piston engine and fuel feeding mechanism therefor

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWMC | Draw De

☐ 2. Document ID: US 4501140 A

L34: Entry 2 of 4 File: USPT Feb 26, 1985

US-PAT-NO: 4501140
DOCUMENT-IDENTIFIER: US 4501140 A

TITLE: Fuel injection rate deducing system for a diesel engine

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWMC | Draw De

☐ 3. Document ID: US 4304129 A

L34: Entry 3 of 4 File: USPT Dec 8, 1981

US-PAT-NO: 4304129
DOCUMENT-IDENTIFIER: US 4304129 A

TITLE: Gas flow measuring apparatus

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWMC | Draw De

☐ 4. Document ID: US 4106448 A

L34: Entry 4 of 4 File: USPT Aug 15, 1978

US-PAT-NO: 4106448
DOCUMENT-IDENTIFIER: US 4106448 A

TITLE: Internal combustion engine and method of operation

Terms	Documents
L33 and (great$ or big$) and small$ and ((cross$ adj section) or "cross-section")	4

Hit List

First Hit

Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Search Results - Record(s) 1 through 10 of 19 returned.

☐ 1. Document ID: US 5211080 A

L48: Entry 1 of 19 File: USPT May 18, 1993

US-PAT-NO: 5211080
DOCUMENT-IDENTIFIER: US 5211080 A

TITLE: Method of shift control during a coastdown shift for an electronic automatic transmission system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 2. Document ID: US 5174334 A

L48: Entry 2 of 19 File: USPT Dec 29, 1992

US-PAT-NO: 5174334
DOCUMENT-IDENTIFIER: US 5174334 A

TITLE: Noise control device for a solenoid-actuated valve

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 3. Document ID: US 5115698 A

L48: Entry 3 of 19 File: USPT May 26, 1992

US-PAT-NO: 5115698
DOCUMENT-IDENTIFIER: US 5115698 A

TITLE: Electronically-controlled, adaptive automatic transmission system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 4. Document ID: US 5027934 A

L48: Entry 4 of 19 File: USPT Jul 2, 1991

US-PAT-NO: 5027934
DOCUMENT-IDENTIFIER: US 5027934 A

TITLE: Double-acting spring in an automatic transmission

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 5. Document ID: US 4982620 A

L48: Entry 5 of 19 File: USPT Jan 8, 1991

US-PAT-NO: 4982620
DOCUMENT-IDENTIFIER: US 4982620 A

TITLE: Method of learning for adaptively controlling an electronic automatic transmission system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 6. Document ID: US 4964506 A

L48: Entry 6 of 19 File: USPT Oct 23, 1990

US-PAT-NO: 4964506
DOCUMENT-IDENTIFIER: US 4964506 A

TITLE: Pressure balanced pistons in an automatic transmission

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 7. Document ID: US 4944200 A

L48: Entry 7 of 19 File: USPT Jul 31, 1990

US-PAT-NO: 4944200
DOCUMENT-IDENTIFIER: US 4944200 A

TITLE: Method of applying reverse gear in an automatic transmission

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 8. Document ID: US 4938102 A

L48: Entry 8 of 19 File: USPT Jul 3, 1990

US-PAT-NO: 4938102
DOCUMENT-IDENTIFIER: US 4938102 A

TITLE: Method of adaptively scheduling a shift for an electronic automatic transmission system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 9. Document ID: US 4936167 A

L48: Entry 9 of 19 File: USPT Jun 26, 1990

US-PAT-NO: 4936167
DOCUMENT-IDENTIFIER: US 4936167 A

TITLE: Method of universally organizing shifts for an automatic transmission system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 10. Document ID: US 4935872 A

L48: Entry 10 of 19 File: USPT Jun 19, 1990

US-PAT-NO: 4935872
DOCUMENT-IDENTIFIER: US 4935872 A

TITLE: Method of shift selection in an electronic automatic transmission system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Terms	Documents
L47 and ((trigger$ or excit$ or actuat$) near2 coil$)	19

Display Format: - Change Format

Previous Page Next Page Go to Doc#

Hit List

First Hit

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Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Search Results - Record(s) 11 through 19 of 19 returned.

☐ 11. Document ID: US 4916961 A

L48: Entry 11 of 19 File: USPT Apr 17, 1990

US-PAT-NO: 4916961
DOCUMENT-IDENTIFIER: US 4916961 A

TITLE: Cam-controlled manual valve in an automatic transmission

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 12. Document ID: US 4915204 A

L48: Entry 12 of 19 File: USPT Apr 10, 1990

US-PAT-NO: 4915204
DOCUMENT-IDENTIFIER: US 4915204 A

TITLE: Push/pull clutch apply piston of an automatic transmission

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 13. Document ID: US 4907681 A

L48: Entry 13 of 19 File: USPT Mar 13, 1990

US-PAT-NO: 4907681
DOCUMENT-IDENTIFIER: US 4907681 A

TITLE: Park locking mechanism for an automatic transmission

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 14. Document ID: US 4907475 A

L48: Entry 14 of 19 File: USPT Mar 13, 1990

US-PAT-NO: 4907475
DOCUMENT-IDENTIFIER: US 4907475 A

TITLE: Fluid switching manually between valves in an automatic transmission

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 15. Document ID: US 4905545 A

L48: Entry 15 of 19 File: USPT Mar 6, 1990

US-PAT-NO: 4905545
DOCUMENT-IDENTIFIER: US 4905545 A

TITLE: Method of controlling the speed change of a kickdown shift for an electronic automatic transmission system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 16. Document ID: US 4887491 A

L48: Entry 16 of 19 File: USPT Dec 19, 1989

US-PAT-NO: 4887491
DOCUMENT-IDENTIFIER: US 4887491 A

TITLE: Solenoid-actuated valve arrangement for a limp-home mode of an automatic transmission

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 17. Document ID: US 4875391 A

L48: Entry 17 of 19 File: USPT Oct 24, 1989

US-PAT-NO: 4875391
DOCUMENT-IDENTIFIER: US 4875391 A

TITLE: Electronically-controlled, adaptive automatic transmission system

Full | Title | Citation | Front | Review | Classification | Date | Reference | Claims | KWIC | Draw D

☐ 18. Document ID: US 4631628 A

L48: Entry 18 of 19 File: USPT Dec 23, 1986

US-PAT-NO: 4631628
DOCUMENT-IDENTIFIER: US 4631628 A

TITLE: Electronic fuel injector driver circuit

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw D

☐ 19. Document ID: US 3131918 A

L48: Entry 19 of 19 File: USOC May 5, 1964

US-PAT-NO: 3131918
DOCUMENT-IDENTIFIER: US 3131918 A

TITLE: Regenerative furnaces

DATE-ISSUED: May 5, 1964

INVENTOR-NAME: THOMAS FALLON JOHN

US-CL-CURRENT: 432/39; 432/133, 432/138, 432/23, 432/72

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw D

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Terms	Documents
L47 and ((trigger$ or excit$ or actuat$) near2 coil$)	19

Display Format: - Change Format

Previous Page Next Page Go to Doc#

L48: Entry 18 of 19 File: USPT Dec 23, 1986

DOCUMENT-IDENTIFIER: US 4631628 A
TITLE: Electronic fuel injector driver circuit

Abstract Text (1):
A method of and apparatus for controlling the energization of an electromagnetic fuel injection valve in response to the production of an injector control pulse in an electronic fuel injection system. The driver circuit operates a current regulating power transistor into saturation until the current through the solenoid coil of the injector valve attains a predetermined peak current value. A comparator circuit deactivates the power transistor to stop the build-up of current through the coil. A switched free-wheeling circuit is enabled, remains activated, and starts conducting when the power transistor is deactivated by the comparator circuit so that some current continues to be supplied to the solenoid coil when the power transistor is off, thereby causing the current through the coil to decay slowly. When the solenoid current has decayed to a predetermined hold current level, the comparator circuit reactivates the power transistor and thereafter, due to hysteresis in the comparator circuit, cycles the power transistor on and off to substantially maintain the current through the coil at the predetermined hold current level. At the end of the injector control pulse, both the current regulating power transistor and the switched free-wheeling circuit are deactivated. Then, through multiple power dissipation pathways momentarily activated by the avalanching of a zener diode in series with the injector's solenoid coil, the energy stored in the solenoid coil and the current through the coil diminish rapidly to zero.

Application Filing Date (1):
19830608

Brief Summary Text (2):
The present invention relates to electronic fuel injection systems for internal combustion engines and in particular to an electronic control circuit for controlling the energization of electromagnetic fuel injection valves.

Brief Summary Text (4):
In throttle body injection systems, the metering of fuel is controlled by an electromagnetic injection valve. A fuel injector typically comprises a precise orifice which is connected through a solenoid valve to a source of pressurized fuel. The valve is actuated via energization of the solenoid coil by a pulsed electrical signal characterized by a pulse width (PW) and a frequency (f). The amount of fuel delivered is thus given by the formula:

Brief Summary Text (11):
In multipoint fuel injection systems, the above control sequence is typically accomplished by operating a power transistor into saturation until the desired peak current is reached, turning the transistor off briefly until the injector current decays to the desired "hold" value, and then maintaining the "hold" current by operating the transistor in its active region until the transistor is turned off at the end of the pulse. However, because of high transistor power dissipation in the active "hold" region, relatively large heat sinks are required. While such heat dissipation is managable in multipoint fuel injection systems where the individual

injectors are fairly small, in throttle body fuel injection systems where a single large injector is utilized to meter fuel flow, the increased force required to move the injector valve requires significantly higher current levels, resulting in commensurately higher levels of heat. For example, the current requirements of a multipoint fuel injector typically are I-peak/I-hold of 2A/0.5A respectively, while those of an exemplary single point fuel injector are 6-8.8A/1.5A. Thus, in automotive throttle body fuel injection applications, the active region method of maintaining "hold" currents may become impractical due to the difficulty of dissipating the increased levels of heat generated.

Brief Summary Text (12):
As a potential solution to this problem, it has been proposed that the desired injector holding current be maintained by rapidly switching the power transistor on and off at an appropriate switching frequency. This approach is taught, for example, in Schultzke et al., U.S. Pat. No. 4,180,026, assigned to Robert Bosch GmbH. The disadvantage of this approach, however, is that the induced voltage which develops in the injector winding during the periods when the transistor is turned off causes the injector current to decay rapidly during shut-off, thus requiring a relatively high switching frequency to avoid injector "chatter" and maintain the desired average holding current level. High switching frequencies can, however, cause switching dissipation and radio frequency interference problems. In addition, performance of the injectors may be less than optimal, particularly at small injector pulse widths.

Brief Summary Text (13):
Accordingly, it is the primary object of the present invention to provide an improved control circuit for an electronic fuel injection system.

Brief Summary Text (14):
In addition, it is an object of the present invention to provide an improved electronic fuel injection control circuit which produces highly consistent delays in the actuation of the fuel injector valve.

Brief Summary Text (15):
Furthermore, it is an object of the present invention to provide an electronic fuel injection control circuit which is capable of precisely controlling relatively large single port fuel injectors without creating a heat dissipation problem.

Brief Summary Text (16):
It is also an object of the present invention to provide an electronic fuel injection control circuit which provides improved linearity in the operation of the fuel injector.

Drawing Description Text (2):
FIG. 1 is a circuit diagram of an electronic fuel injector driver circuit according to the present invention; and

Drawing Description Text (3):
FIG. 2 is a timing diagram illustrating the operation of the electronic fuel injector driver circuit shown in FIG. 1.

Detailed Description Text (2):
Referring to FIG. 1, an electronic fuel injector driver circuit according to the present invention is shown. While the preferred embodiment of the present invention described herein is particularly suited for application with single-point throttle-body type fuel injection systems, it will be readily apparent that the invention is equally applicable to multi-point port-type fuel injection systems as well.

Detailed Description Text (3):
The solenoid coil which actuates the injector valve is adapted to be connected

across the terminals designated "Injector 1" and "Injector 2". The "Switched Battery" terminal is connected through the ignition switch of the vehicle to the battery, and the 5.0 volts supply line 20 is connected to a five volts regulated output of a power supply. The injector control pulse, which is produced by the main fuel injection control circuit (not shown) to signal the actuation of the injector, is supplied on line 17 and is designated INJ, as the presence of an injector pulse corresponds to a positive-going or HI logic pulse. The INJ signal is inverted via transistor QA to create an INJ signal on line 18. Operational amplifiers 22 and 24 are logic comparators of the open collector type adapted to produce an open (HI) signal at their output when the signal at their positive input exceeds the signal at their negative input and a LO output signal when the signal at their negative input exceeds the signal at their positive input. The transistors having a "U"-shaped designation adjacent the collector terminal, namely transistors Q120 and Q4, indicate power transistors which are mounted to a heat sink.

Detailed Description Text (4):
In general, the present fuel injector driver circuit 10 comprises a drive transistor Q120 which is connected in series with the injector coil (not shown but to be connected between the terminals labeled Injector 1 and 2), and a current sensing resistor R8 between the switched battery line 16 and ground, for controlling energization of the injector coil. Actuation of transistor Q120 is in turn controlled by switching transistor Q21 which has its base terminal connected to the INJ control line 18. Accordingly, when a HI injector control pulse on line 17 produces a LO signal on line 18, transistor Q21 is turned on, thereby forward biasing transistor Q120 and energizing the injector coil. During the injector pulse, the switching of transistor Q120 serves to regulate the current flow from line 16 to the injector coil, and this switching is controlled by comparators 22 and 24 and the current sensing resistor R8. In addition, a clamping transistor Q4 and a free-wheeling diode D3 are connected in series to the injector coil to provide a second current path to the injector coil, which (on account of the connection of transistor Q4 to transistor Q21 through resistor R15) remains enabled or activated throughout the duration of the injector control pulse, even when transistor Q120 is turned off. The purpose of this second current path will be subsequently explained in greater detail.

Detailed Description Text (14):
Thus, it will be appreciated that the present injector driver circuit initially operates the power transistor Q120 in saturation until the desired peak current is reached, and then allows the injector current to decay slowly through current-limited free-wheeling diode-transistor path while the current regulating power transistor Q120 is turned off until the desired hold current level is attained. Thereafter, the power transistor Q120 is cycled on and off at a relatively low frequency to maintain the injector current at the desired hold current level. At the end of the injector control pulse, both the power transistor and the switched free-wheeling diode path are deactivated to allow a large induced voltage and current to momentarily develop across the injector winding to facilitate very rapid but controlled decay of the power stored in the injector coil's magnetic field.

CLAIMS:

1. An electronic driver circuit for controlling the energization of a solenoid coil, forming part of an electromagnetic fuel injection valve, in response to an injector control pulse, produced by a main fuel injection control circuit, comprising:

a current regulating circuit including a power transistor connected in series with said coil, forming part of an electromagnetic fuel injection valve, and a current sensing resistor between a power source and ground, and a first switching transistor responsive to said injector control pulse, produced by a main fuel injection control circuit, for controlling the actuation of said power transistor;

a free-wheeling circuit connected in parallel with said power transistor and including a diode and a second switching transistor actuation of which is also controlled by said first switching transistor so that said free-wheeling circuit is operative to allow current to flow to said solenoid coil, forming part of an electromagnetic fuel injection valve, during said injector control pulse, produced by a main fuel injection control circuit;

a first comparator having one input thereof connected to said current sensing resistor and its other input thereof connected to receive a first reference signal from a reference circuit, said first reference signal being set so that said first comparator switches output states when the current through said coil attains a predetermined peak current value; the output of said first comparator being connected to said reference circuit for changing the value of said first reference signal when said first comparator switches output states so that said first comparator will not switch back to its original output state until the current through said coil, forming part of an electromagnetic fuel injection valve, is substantially equal to zero; and

a second comparator having its output connected to a third switching transistor which is in turn connected to said power transistor for controlling the actuation of said power transistor, said second comparator having one input thereof connected to said current sensing resistor and its other input connected to receive a second reference signal from said reference circuit; said second reference signal being set so that initially said second comparator switches output states in response to said first comparator switching output states to thereby actuate said third switching transistor and deactuate said power transistor; said second reference signal being thereafter changed by the effect of the switched output state of said first comparator on said reference circuit to a voltage value substantially equal to the voltage across said current sensing resistor when the current through said coil, forming part of an electromagnetic fuel injection valve, is equal to a predetermined hold current level; said second comparator further having positive feedback for providing a hysteresis effect to said second comparator for oscillating the output of said second comparator to cycle said power transistor on and off to substantially maintain the current through said coil, forming part of an electromagnetic fuel injection valve, at said predetermined hold current level;

said free-wheeling circuit remaining actuated during the off periods of said power transistor so that the current through said coil, forming part of an electromagnetic fuel injection valve, decays slowly when said power transistor is off.

4. The driver circuit of claim 1 further comprising multiple pathway power dissipation means for rapidly and controlledly dissipating energy stored in said solenoid coil, forming part of an electromagnetic fuel injection valve, through multiple pathways upon termination of said injector control pulse, produced by a main fuel injection control circuit.

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L48: Entry 18 of 19 File: USPT Dec 23, 1986

US-PAT-NO: 4631628
DOCUMENT-IDENTIFIER: US 4631628 A

TITLE: Electronic fuel injector driver circuit

DATE-ISSUED: December 23, 1986

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
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ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
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APPL-NO: 06/502410 [PALM]
DATE FILED: June 8, 1983

INT-CL-ISSUED: [04] H01H 47/32

INT-CL-CURRENT:

TYPE	IPC	DATE
CIPS	F02 D 41/20	20060101
CIPS	H01 H 47/22	20060101
CIPS	H01 H 47/32	20060101

US-CL-ISSUED: 361/154; 123/490
US-CL-CURRENT: 361/154; 123/490

FIELD-OF-CLASSIFICATION-SEARCH: 361/152, 361/153, 361/154, 361/155, 123/490
See application file for complete search history.

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	4176387	November 1979	Harper	361/154
☐	4180026	December 1979	Schulzke et al.	123/32EF

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	CLASS
27530	March 1981	JP	361/154

ART-UNIT: 211

PRIMARY-EXAMINER: Gellner; Michael L.

ATTY-AGENT-FIRM: Calcaterra; Mark P.

ABSTRACT:

A method of and apparatus for controlling the energization of an electromagnetic fuel injection valve in response to the production of an injector control pulse in an electronic fuel injection system. The driver circuit operates a current regulating power transistor into saturation until the current through the solenoid coil of the injector valve attains a predetermined peak current value. A comparator circuit deactivates the power transistor to stop the build-up of current through the coil. A switched free-wheeling circuit is enabled, remains activated, and starts conducting when the power transistor is deactivated by the comparator circuit so that some current continues to be supplied to the solenoid coil when the power transistor is off, thereby causing the current through the coil to decay slowly. When the solenoid current has decayed to a predetermined hold current level, the comparator circuit reactivates the power transistor and thereafter, due to hysteresis in the comparator circuit, cycles the power transistor on and off to substantially maintain the current through the coil at the predetermined hold current level. At the end of the injector control pulse, both the current regulating power transistor and the switched free-wheeling circuit are deactivated. Then, through multiple power dissipation pathways momentarily activated by the avalanching of a zener diode in series with the injector's solenoid coil, the energy stored in the solenoid coil and the current through the coil diminish rapidly to zero.

4 Claims, 2 Drawing figures

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L58: Entry 1 of 1 File: PGPB Feb 26, 2004

DOCUMENT-IDENTIFIER: US 20040039514 A1
TITLE: Method and apparatus for controlling a gas-emitting process and related devices

Summary of Invention Paragraph:
[0003] The underlying objective of the ECU is to provide performance that optimizes fuel efficiency, drivability and reduction of harmful emissions. Signals concerning the state or condition of various operating characteristics of the engine are fed to the ECU. Typical engine operating characteristics as to which signals are inputted to the ECU are throttle position, intake manifold pressure, intake airflow, crank position, engine torque and air-to-fuel ratio (referred to as "lambda") value. Engine operating characteristics that may be adjusted for control in view of such inputs include fuel injection timing, spark advance, air-to-fuel ratio, exhaust gas recycle ("EGR") and idle air control motor. Although an engine is essentially a chemical plant oxidizing fuel with air into water, carbon dioxide and other chemical species, the only sensor currently capable of providing any information about the chemical status of the combustion process is the lambda sensor, which is limited to inferring a value for the air-to-fuel ratio of the engine based on measurements made in the stream of exhaust gases.

Detail Description Paragraph:
[0034] In the intake passage 38, there is provided a fuel injection valve 42 located in the vicinity of the intake port 30. The intake passage 38 further has a throttle valve 44 and an air-flow detector 46, which is located upstream of the throttle valve 44. At the upstream end of the intake passage 38, there is an air cleaner 48. In the exhaust passage 40, there is an air/fuel ratio (lambda) detector 50. Further, the exhaust passage 40 is provided with a catalytic device 52 of a type as known in the art. The engine is further provided with a sensor 54, such as an engine speed detector.

Detail Description Paragraph:
[0035] The fuel injection valve 42 is connected with a fuel supply source (not shown) and supplied with fuel under a controlled pressure. The valve 42 may be of the duty factor solenoid type in which the quantity of fuel injected through the valve 42 is determined by the duty factor of electric pulses applied to the valve 42. The CPU 4 actuates the valve 42 to control the quantity of fuel supplied to the engine, which is a parameter of the chemical reaction embodied in combustion.

Detail Description Paragraph:
[0036] The CPU 4 is connected with the outputs of sensors and detectors, preferably those that supply information about the compositional content of the exhaust gases, applies the decision-making routine to those outputs, and in turn produces output pulses that are routed to the fuel injection valve 42. The CPU 4 functions to calculate the quantity of fuel to be supplied to the engine on the basis of the engine operating condition as detected by various sensors and detectors so that a desired air-fuel ratio is established. For example, in a normal engine operating condition, it is preferred to maintain the stoichiometric air-fuel ratio, and the CPU 4 will in such case produce a basic fuel quantity signal which corresponds to

the fuel quantity required for providing an air-fuel mixture of the stoichiometric ratio. The reaction of combustion may also be controlled by adjusting the amount of oxygen (or oxygen source such as air) fed to the cylinder, or adjusting the spark advance in relation to information about the compositional content of the exhaust gases.

Detail Description Paragraph:
[0037] Of equal importance is the use of the methods and apparatus of this invention to control a device to which a product of a chemical reaction is transmitted. In the case of the combustion reaction in an engine, the exhaust gas stream itself is a product of the reaction, and it is transmitted to various devices such as the exhaust gas recirculation system or a pollution abatement device such as a catalytic converter and/or a device for the storage or abatement (reduction) of NO.sub.x. Information about the compositional content of the exhaust stream can be inputted from sensors and detectors to the ECU, which can utilize that information in a decision-making routine to output signals that control, for example, the settings on an exhaust recirculation valve, the extent of injection into an SCR catalytic converter of a reducing agent, or the regeneration of a NO.sub.x, catalyst when contaminated with sulfur. Typical exhaust gases include oxygen, carbon monoxide, hydrogen, sulfur dioxide, ammonia, CO.sub.2, H.sub.2S, methanol, water, a hydrocarbon (such as C.sub.nH.sub.2n+2, and as same may be saturated or unsaturated, or be optionally substituted with hetero atoms; and cyclic and aromatic analogs thereof), a nitrogen oxide (such as NO, NO.sub.2, N.sub.2O or N.sub.2O.sub.4) or an oxygenated carbon (CO, CO.sub.2 or C.sub.5O.sub.3). In certain embodiments, gases of interest may include one or more of NO.sub.x, hydrocarbons and ammonia. In certain other embodiments, however, it may be desired that the methods and apparatus not provide any signals, measurements, information or analysis with respect to oxygen.

Detail Description Paragraph:
[0049] FIGS. 7 and 8 show several possible locations of an array of sensor materials in an exhaust system. The engine in FIGS. 7 and 8 contains a mass airflow and outside temperature sensor 60, an idle air valve 62, a throttle position valve 64, an exhaust gas recycle valve 66, an air temperature sensor 68, a pressure sensor 70, an air intake 72, an intake manifold 74, fuel injectors 76, spark plugs 78, a crank position sensor 80, a cam position sensor 82, a coolant temperature sensor 84, a pre-catalytic converter 86, an emissions control device (such as a catalytic converter and/or a device for the storage or abatement of NO.sub.x) 90, and a temperature sensor 92. FIG. 7 shows three possible locations 94, 96, 98 for an array of chemo/electro-active materials, which may be upstream or downstream from the emissions control device. The arrows indicate the locations where it would be possible, if desired, to provide for the flow of information to/from the ECU to/from one or more sensors or acctuators. Information gathered from an array of chemo/electro-active materials and processed by the ECU could be used, for example, to control the exhaust gas recycle valve 66 or the fuel injectors 76.

Detail Description Paragraph:
[0058] catalytic conditions, as regulated by rate of movement of a moving bed, or frequency of catalyst regeneration;

Detail Description Paragraph:
[0079] This invention is useful for detecting those gases that are expected to be present in a gas stream. For example, in a combustion process, gases that are expected to be present include oxygen, nitrogen oxides (such as NO, NO.sub.2, N.sub.2O or N.sub.2O.sub.4), carbon monoxide, hydrocarbons (such as CnH.sub.2n+2, and as same may be saturated or unsaturated, or be optionally substituted with hetero atoms; and cyclic and aromatic analogs thereof), ammonia or hydrogen sulfide, sulfur dioxide, CO.sub.2, or methanol. Other gases of interest may include alcohol vapors, solvent vapors, hydrogen, water vapor, and those deriving from saturated and unsaturated hydrocarbons, ethers, ketones, aldehydes, carbonyls,

biomolecules and microorganisms. The component of a multi-component gas mixture that is an analyte of interest may be an individual gas such as carbon monoxide; may be a subgroup of some but not all of the gases contained in the mixture, such as the nitrogen oxides (NO.sub.x,) or hydrocarbons; or may be a combination of one or more individual gases and one or more subgroups. When a subgroup of gases is an analyte, a chemo/electro-active material will respond to the collective concentration within a multi-component gas mixture of the members of the subgroup together.

Detail Description Paragraph:
[0396] An electrical response is determined for each individual chemo/electro-active material separately from that of each of the other chemo/electro-active materials. This can be accomplished by accessing each chemo/electro-active material with an electric current sequentially, using a multiplexer to provide signals differentiated between one material and another in, for example, the time domain or frequency domain. It is consequently preferred that no chemo/electro-active material be joined in a series circuit with any other such material. One electrode, by which a current is passed to a chemo/electro-active material, can nevertheless be laid out to have contact with more than one material. An electrode may have contact with all, or fewer than all, of the chemo/electro-active materials in an array. For example, if an array has 12 chemo/electro-active materials, an electrode may have contact with each member of a group of 2, 3, 4, 5 or 6 (or, optionally, more in each instance) of the chemo/electro-active materials. The electrode will preferably be laid out to permit an electrical current to be passed to each member of such group of chemo/electro-active materials sequentially.

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L58: Entry 1 of 1 File: PGPB Feb 26, 2004

PGPUB-DOCUMENT-NUMBER: 20040039514
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20040039514 A1

TITLE: Method and apparatus for controlling a gas-emitting process and related devices

PUBLICATION-DATE: February 26, 2004

INVENTOR-INFORMATION:

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APPL-NO: 10/406970 [PALM]
DATE FILED: October 14, 2003

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Application is a non-provisional-of-provisional application 60/370445, filed April 5, 2002,

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INT-CL-CURRENT:

TYPE	IPC	DATE
CIPS	F01 N 11/00	20060101
CIPS	F02 D 41/14	20060101
CIPN	F01 N 3/08	20060101
CIPN	F01 N 3/20	20060101

US-CL-PUBLISHED: 701/109; 123/703, 123/674, 700/32
US-CL-CURRENT: 701/109; 123/674, 123/703, 700/32

REPRESENTATIVE-FIGURES: 6

ABSTRACT:

Disclosed herein is a method and apparatus for controlling a process, such as a chemical reaction, that emits a multi-component mixture of gases; and for controlling a device to which is transmitted a product of a chemical reaction that emits a multi-component mixture of gases.

L35: Entry 1 of 1 File: USPT Aug 15, 1978

US-PAT-NO: 4106448
DOCUMENT-IDENTIFIER: US 4106448 A

TITLE: Internal combustion engine and method of operation

DATE-ISSUED: August 15, 1978

INVENTOR-INFORMATION:

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Tanaka; Yukiyasu	Okazaki			JP
Tanaka; Taro	Chiryu			JP

ASSIGNEE-INFORMATION:

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APPL-NO: 05/657201 [PALM]
DATE FILED: February 11, 1976

FOREIGN-APPL-PRIORITY-DATA:

COUNTRY	APPL-NO	APPL-DATE
JP	50-26375	March 3, 1975
JP	50-29232	March 10, 1975
JP	50-33719	March 19, 1975
JP	50-40709	April 2, 1975
JP	50-41692	April 4, 1975
JP	50-45685	April 14, 1975
JP	50-47926	April 21, 1975
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JP	50-58234	May 15, 1975
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JP	50-71774	June 12, 1975
JP	50-71778	June 12, 1975
JP	50-74958	June 18, 1975
JP	50-80419	June 28, 1975

INT-CL-ISSUED: [02] F02M 7/00, F02P 5/04, F02B 19/10, F02B 19/16

INT-CL-CURRENT:

TYPE	IPC	DATE
CIPS	F02 D 41/00	20060101
CIPS	F02 D 37/00	20060101
CIPS	F02 D 41/24	20060101
CIPS	F02 B 1/06	20060101
CIPS	F02 B 19/00	20060101
CIPS	F02 B 19/10	20060101
CIPS	F02 B 1/00	20060101
CIPS	F02 P 5/15	20060101
CIPS	F02 D 37/02	20060101

US-CL-ISSUED: 123/119LR; 60/285, 123/117R, 123/117A, 123/119A, 123/119A, 123/32SP, 123/198F, 123/32EB
US-CL-CURRENT: 123/268; 123/198F, 123/275, 123/443, 123/486, 123/568.27, 123/699, 60/285

FIELD-OF-CLASSIFICATION-SEARCH: 123/32SP, 123/32ST, 123/32EA, 123/32EB, 123/119LR, 123/127, 60/285, 60/274, 60/276, 60/278
See application file for complete search history.

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

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	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	2166968	July 1939	Rohlin	123/198F
☐	2771867	November 1956	Peras	123/198F
☐	3708980	January 1973	Truxell	60/276
☐	3827237	August 1974	Linder	60/285
☐	3910240	October 1975	Omori	123/32EA
☐	3982393	September 1976	Masaki	60/274
☐	4030292	June 1977	Masaki et al.	60/285
☐	4033122	July 1977	Masaki et al.	60/285

ART-UNIT: 342

PRIMARY-EXAMINER: Cox; Ronald B.

ATTY-AGENT-FIRM: Cushman, Darby & Cushman

ABSTRACT:

All of combustion chambers receive a lean air-fuel charge at low and medium engine

power demands. As the engine power demand increases, a rich air-fuel charge is supplied to one or a suitable number of the combustion chambers with countermeasures being provided to suppress the formation of nitrogen oxides, such as, an exhaust gas recirculation (EGR) and the torch effect of a torch ignition system, the remaining combustion chambers, if any, receiving a lean air-fuel charge.

Exhaust gases from all of the combustion chambers are converged to oxidize hydrocarbons and carbon monoxide formed by the combustion of the rich air-fuel charge when the combustion chambers respectively receive rich and lean air-fuel charges.

254 Claims, 44 Drawing figures

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